Lower eyelid complications associated with transconjunctival versus subciliary approaches to orbital floor fractures

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Table of contents

Bibliographische Beschreibung

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Abstract:

Subciliary and transconjunctival approaches are commonly used to enter the orbital floor. Although both surgical approaches have been used for decades, there is no consensus regarding the most appropriate incision to prevent postoperative lower eyelid complications. The aim of this study was to compare the frequencies of lower eyelid complications after subciliary versus transconjunctival approaches to orbital floor fractures.

The investigator implemented a retrospective cohort study and enrolled a sample consisting of subjects who had orbital floor repair. The predictor variable was two different surgical methods, subciliary or transconjunctival approch. The primary outcome variable was postoperative lower eyelid complications (ectropion, entropion, and eyelid retraction). Other variables were demographic backgrounds, anatomical consideration, or time to surgery. The samples were composed of 346 patients (98 [28.3%] females; 225 [65%] underwent a subciliary approach) with a mean age of 42.7 ± 21.1 years. The subciliary approach was significantly linked to the higher rates of ectropion and the lower rates of entropion at 7 days and 6 months postoperatively. There was no statistically significant difference in the frequency of eyelid retraction between both groups.

In the setting of orbital floor fractures, these results suggest that the use of the subciliary approach increases the frequency of ectropion, while the transconjunctival approach increases the frequency of entropion. Consequently, the selection should be based on an individual patient basis and surgeon's preference.

1 Introduction

For treatment of orbital wall fractures, various transcutaneous and transmucosal approaches are commonly used to enter the orbital cavity. Subciliary and transconjunctival incisions are the most frequent techniques worldwide to access the orbital floor. Although both surgical approaches have been used for decades, there is no consensus regarding the most appropriate incision to prevent postoperative lower eyelid complications. Plastic and oromaxillofacial surgeons favor the subciliary incision, whereas opthalmologists and otorhinolaryngologists prefer the transconjunctival approach. The possible postoperative lower eyelid complications after orbital floor fracture treatment are ectropion, entropion, and eyelid retraction. Ectropion is the most common problem. Given the frequency and associated morbidity of eyelid complications, identifying approaches to decrease the frequency of these complications may be important to improve patient outcomes after orbital floor fracture treatment.

2 Surgical anatomy of the orbit

2.1 The bony orbit

The bony orbit is a roughly quadrilateral, pyramidal cavity with its base directed forwards and laterally. It is comprised of 7 bones including: maxilla, palatine, frontal, zygomatic, sphenoid, ethmoid and lacrimal bones. The roof of the orbit consists of the orbital plate of frontal bone anteriorly and the lesser wing of sphenoid bone posteriorly. It is thin but reinforced laterally by the greater wing of sphenoid bone and the superior orbital rim. The lateral orbital wall is the strongest wall of the orbit. It consists of the orbital surface of zygomatic bone, which is thick at the orbital rim and the greater wing of sphenoid. It inclines at 45 degree to the anteroposterior axis of the skull. A frontal view of the bony orbit is demonstrated in Figure 1.

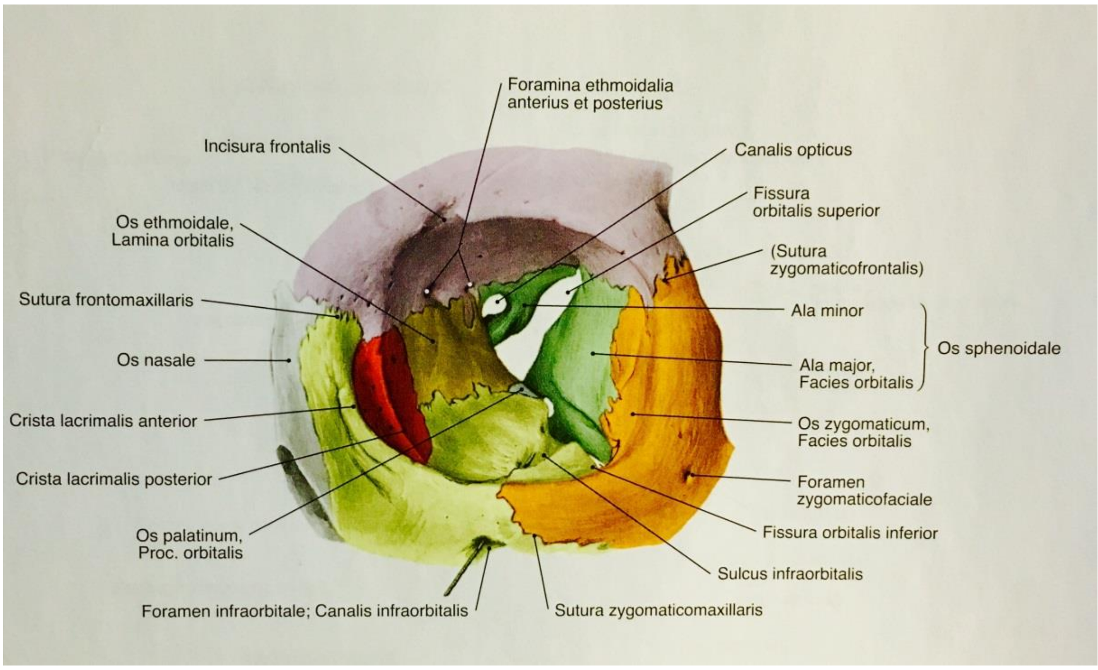

Figure 1: Frontal view of the bony orbit (Sabotta: Atlas der Anatomie des Menschen 1. Urban and Schwarzenberg, 22nd edition, page 54).[4]

The medial wall consists of the orbital plate of ethmoid bone centrally, the frontal bone anterosuperiorly, the lacrimal bone antereoinferiorly and the sphenoid bone posteriorly. The medial wall is formed basically from the thin orbital plate of the ethmoid bone and is aligned parallel to the anteroposterior axis of skull. Being adjacent to the ethmoidal air cells, and more anteriorly to the nasal cavity, the medial wall is fragile and thus it is frequently grossly disrupted in nasoethmoidal fractures with lateral displacement, giving the classical sign of hypertelorism. At the level of the optic foramen, close to the junction of the medial orbital wall and roof, there are two to three foramina through which pass branches of the ethmoidal artery. These foramina are important landmarks during the dissection of this region.

The floor of the orbit consists of the orbital plate of maxilla and the zygomatic bone anterolaterally and the orbital plate of palatine bone posteriorly. The floor of the orbit is the prevalent site involved with pure blow-out fractures of the orbit. It slopes upward and medially until it becomes horizontal as it approaches the anterior margin of the inferior orbital fissure. The floor then curves downwards steeply into the infratemporal fossa to form the posterior wall of maxillary antrum. Reconstruction of the orbital floor which involves this area therefore requires special attention to re-establish this sigmoid shape. The orbital floor is very thin and it is further weakened by the presence of the infraorbital groove and canal. Most of the blow-out fractures of the orbital floor occur immediately medial to the infraorbital groove and canal, and therefore frequently involve the infraorbital nerves and vessels, either by compression or contusion.[1-7]

2.2 Soft tissues of the orbit

The eyelids are covered by a thin skin which overlies a loose areolar tissue. It has a profuse blood supply. Opening of the eye is achieved by levator palpebrae superioris muscle, which is innervated by the oculomotor nerve. Eye closure is carried out by the orbicularis oculi, supplied by the facial nerve. Orbicularis oculi muscle is demonstrated in Figure 2).

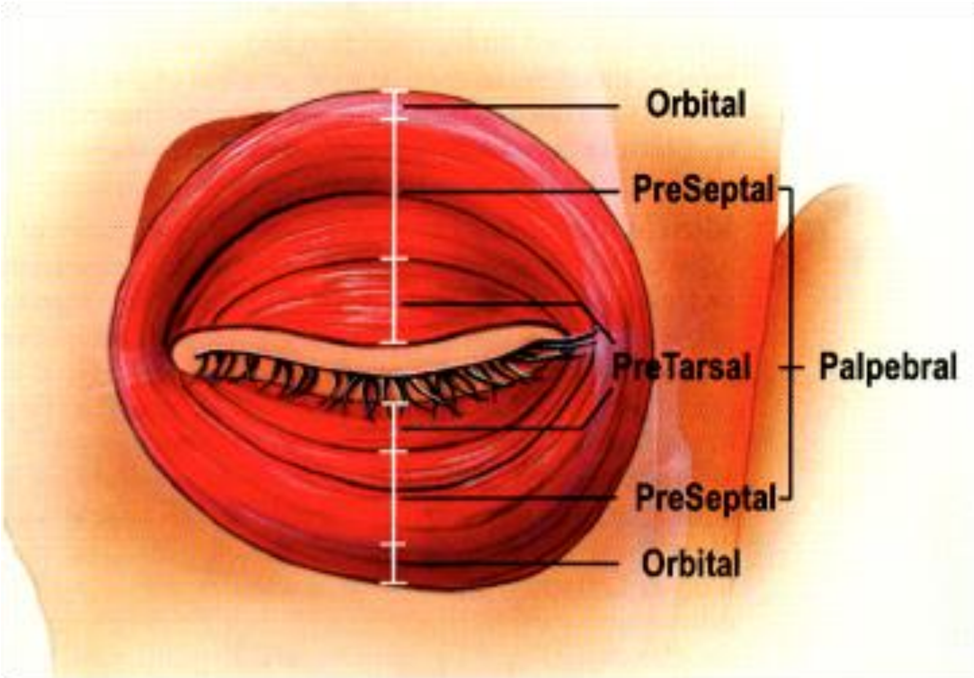

Figure 2: Orbital and palpebral portions of orbicularis oculi muscle. The palpebral portion is divided into the fibers in front of the tarsus (pretarsal portion) and those in front of the orbital septum (preseptal portion) (Surgical approaches to the facial skeleton, Edward Ellis III and Michael F.Zide, 2006, 2nd edition, page 12.).[39]

The orbital septum (Figure3) consists of a fibrous diaphragm extending from the periphery of the orbit to the tarsal plates. This septum prevents the escape of blood or pus outside the orbit if present with the orbit. Collections within this compartment may therefore lead to an increase in the retrobulbar pressure, which may cause vascular occlusion and hence interfere with the circulation to the retina and consequently affect sight. Retrobulbar collections are, therefore considered a surgical emergency. Because the orbital septum is incomplete in its medial and inferior aspect, a nasoethmoidal fracture may result in peri-orbital emphysema of the lids with subsequent air collection anterior to the tarsal plates, often associated with the nose blowing. The emphysema usually spontaneously resolves, although may need decompression if significant.

The tarsal plates form the skeleton of the eyelids, are semilunar in shape, and are formed by dense connective tissue. The canthal (palpebral) ligaments are two almost Y shaped fibrous extentions of the tarsal plates to the lateral and medial walls.

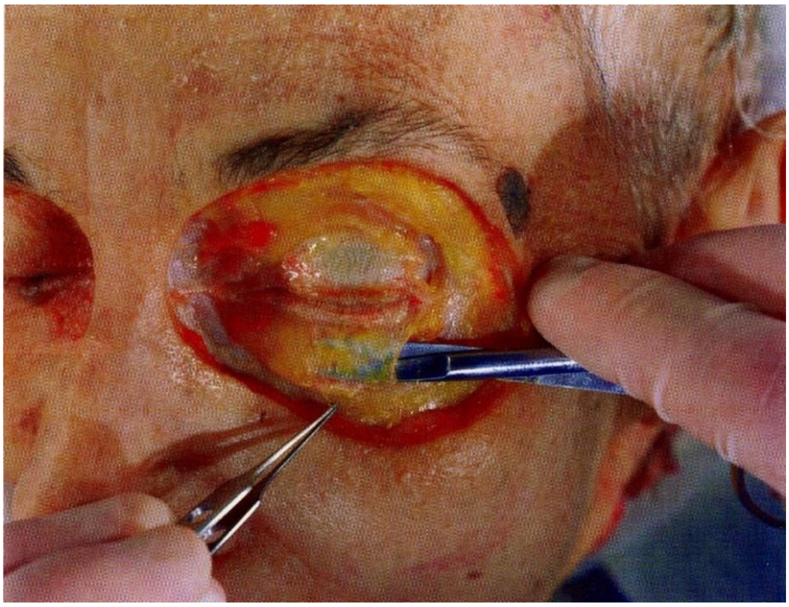

Figure 3: Anatomic dissection of orbital septum in the lower eyelid (Surgical approaches to the facial skeleton, Edward Ellis III and Michael F.Zide, 2006, 2nd edition, page 11.).[39]

The conjunctiva is a highly vascular structure, except in the area which covers the cornea which is devoid of blood vessels. Subconjunctival heamorrhage hence ceases at the corneal margin. It has a firm attachment in the palpebral portion but loose attachment where it covers the sclera. The lacrimal apparatus is involved in the production of tears and the removal of excess tears. The lacrimal apparatus consists of the lacrimal gland, lacrimal canaliculi, lacrimal sac and the nasolacrimal duct. Under normal conditions the lacrimal gland secretes just enough tears to replace those lost by evaporation. There is a layer of periorbital fat which acts as a cushion upon which the extra-ocular muscles of the eye can move and rotate the eyeball within the capsule of Tenon, which is a thin membrane which envelops the eyeball from the optic nerve to the limbus. There are a large number of fibrous septa within the periorbital fat, which may become entrapped with the fat in orbital blowout fractures lead to interference with the free movement of the extraocular muscles. Periorbital fat fills both intraconal and extraconal spaces.

The anatomic and histological study of the orbit, found a fine ligament system, interconnecting the orbital soft tissue with the bony orbit. The presence of such a ligament system could play an important role in extraocular muscle motility defects, without the need for actual muscle entrapment.[1-7]

2.2.1 Muscles of the orbit (extraocular muscles)

The eyeball is moved chiefly by six extrinsic muscles: four recti and two oblique muscles (Figure 4). These skeletal muscles arise from the posterior aspect of the orbit (except for the inferior oblique muscle) and are inserted into the sclera.

The four recti arise from a common tendinous ring that surrounds the optic canal and a part of the superior orbital fissure. All the structures that enter the orbit through the optic canal and adjacent part of the fissure lie at first within the cone of the recti. The four muscles are inserted into the anterior portion of the sclera, 6-8 mm posterior to the sclerocorneal junction.

The superior oblique muscle arises from the sphenoid bone superomedial to the optic canal. It passes anteriorward, superior to the medial rectus, and through a cartilaginous pulley (the trochlea) attached to the frontal bone. The tendon is thereby directed posterolaterally, running inferior to the tendon of the superior rectus to insert into the posterior sclera. The inferior oblique muscle arises from the maxilla at the anteromedial floor of the orbit, passes in a posterolateral direction, immediately inferior to the inferior rectus to insert into the posterior sclera.

A mock chemical formula is often used an aid to memorizing the cranial nerve supplies of the eye muscles: LR6SO4, indicating that the lateral rectus is supplied by the sixth (abducent) nerve and the superior oblique by the fourth nerve (trochlear). All other muscles (superior, medial and inferior rectus and inferior oblique) are supplied by the third nerve (oculomotor).

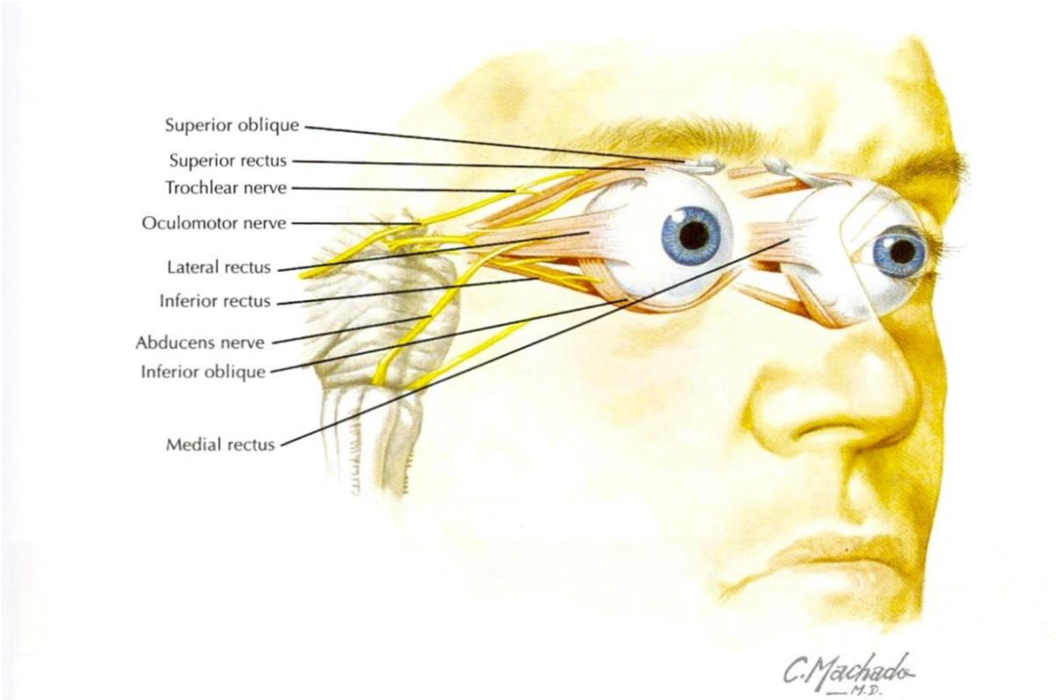

Figure 4: The extrinsic ocular muscles (Netter´s Head and Neck anatomy for dentistry, Neil S. Norton, 2007, 1^{st} edition, page 513).[7]

The eye is poised in the fascia and fat of the orbit, and equilibrium is maintained by all the muscles, none of which ever acts alone. Moreover, the two eyes move together in unison (conjugately). Movements may be considered to be around a vertical axis (abduction and adduction), a lateromedial axis (elevation and depression) and even an anteroposterior axis (extorsion and intorsion).

The recti extend from the posterior aspect of the orbit to the anterior aspect of the sclera. The lateral and medial recti are purely an abductor and an adductor, respectively. The superior and inferior recti elevate and depress, respectively, and because of their lateral course, are the only muscles that can do so when the eye is abducted.The trochlea of the superior oblique muscle serves as its functional origin, and hence the two oblique muscles may be said to extend from the anteromedial orbit to the posterior sclera. The superior and inferior oblique muscles depress and elevate, respectively, and because of their lateral course, are the only muscles that can do so when the eye is adducted.

Paralysis of an extrinsic eye muscle is noted by (1) limitation of movement in the field of action of the paralyzed muscle and (2) the presence of two images (diplopia) that are separated maximally when an attempt is made to move the eye in the direction of primary action of the paralyzed muscle.[1-7]

2.2.2 Nerves of the orbit

The optic nerve is essentially an extension of the brain and is covered by dura, arachnoid and pia mater. In contrast to the immobile intracanalicular portion of the nerve, the orbital portion enjoys considerable mobility which decreases the likelihood of its injury in orbital trauma. The infraorbital nerve enters the orbit accompanied by the zygomatic nerve and infraorbital artery. The infraorbital nerve and artery occupy a groove in the posterior part of the orbital floor. Both enter the infraorbital canal and continue to the face, supplying nerves to the maxillary sinus and the anterior teeth en route.

The zygomatic nerve passes along the lateral wall and divides into its zygomaticotemporal and zygomaticofacial branches. The former gives secretomotor fibers to the lacrimal nerve for the lacrimal gland.

The oculomotor and the abducent nerves are situated inside the tendinous ring, and are therefore better protected than the trochlear nerve, which is more vulnerable along its course as it crosses above the origin of the levator and the muscle cone running along the upper part of the medial wall. The nerve to the inferior oblique muscle leaves the protection of the muscles between the inferior rectus and the lateral rectus and is at risk because of its proximity to the floor of the orbit.[1-7]

2.2.3 Vessels of the orbit

The ophthalmic artery, a branch of the internal carotid artery, enters the orbit through the optic canal within the dural sheath of the optic nerve. It gives off several branches. The blood supply to retina is derived from the central retinal artery, a branch of the ophthalmic artery.[1-7]

2.2.4 The globe of the eye

The eye contains the light sensitive retina and it is provided with a lens system, the cornea, lens and refractive media, for focusing images and with means of controlling the light admitted, the iris diaphragm. The inside of the globe is black to prevent internal reflections; the large area behind the lens is occupied by the vitreous body. In front of the lens a small area is filled by aqueous humour, the two compartments being incompletely divided into the anterior and posterior chambers by the iris. The space bounded by the inner margin of the iris is the pupil. The wall of the eye, enclosing the refractive media is made up of three coats. The outer coat is fibrous and consists of the sclera and cornea; a vascular coat, the choroid, ciliary body and iris; and the innermost nervous coat, the retina. The sclera can be considered as a ‘cup-like’ expansion of the dural sheath of the optic nerve. The choroid could be also considered as an expansion of the arachnoid and pia, while the retina being an expansion of the optic nerve.[1-7]

3 Orbital fractures

3.1 Classification of orbital fracture

Regarding the orbital fracture classification system for surgical purposes, the bony orbit is divided into the orbital frame and the orbital walls. Both subunits consist of several bony components of different anatomical origin. Thus, fractures involving the orbit may affect a changing pattern of related bones. Under clinical aspects they are described as follows.[8]

• Orbitozygomatic fractures (OZM), if the malar bone is the area of impact.

• Nasoorbitoethmoidal fractures (NOE), if the trauma is directed to the central upper midface.

• Internal orbital fractures or orbital wall fractures (blow-out, blow-in), if only the orbital walls and not the frame are involved.

• Combined orbital fractures, if the entire orbital skeleton is involved.

For the classification of orbital fractures, the orbital walls are assessed independently from the bones that they originate from (geometric concept).

3.2 Classification of blow-out fracture

An orbital blowout fracture is a traumatic deformity of the orbital floor or medial wall. It seems that there is no widely approved classification for blow-out fracture. Most of the available classifications are more likely attempts to establish CT scan criteria for blow-out fracture. There are two broad categories of blowout fractures: open door, which are large, displaced and comminuted, and trap-door, which are linear, hinged, and minimally displaced.

A more recent classification suggested by Yano et al., for the sake of simplicity of fracture description, divides blow-out fractures into: linear type, punched-out type, and burst type. Linear fractures are used to describe fractures with minimally dislocated bone fragments. Punched-out fractures are used for fractures involving less than one-third of the floor. Burst fractures are the fractures which involve more than two-thirds of the orbital wall.[9] Poeschl et al. adopted the same classification, they used the “punched-out” fracture term for fractures less than half of the orbital floor, and the “burst” fracture term for fractures involving more than half of the orbital floor.[10]

3.3 Mechanisms of orbital floor fracture

Two main theories have been postulated, including the hydraulic theory, and the bone buckling theory (Figure 5).

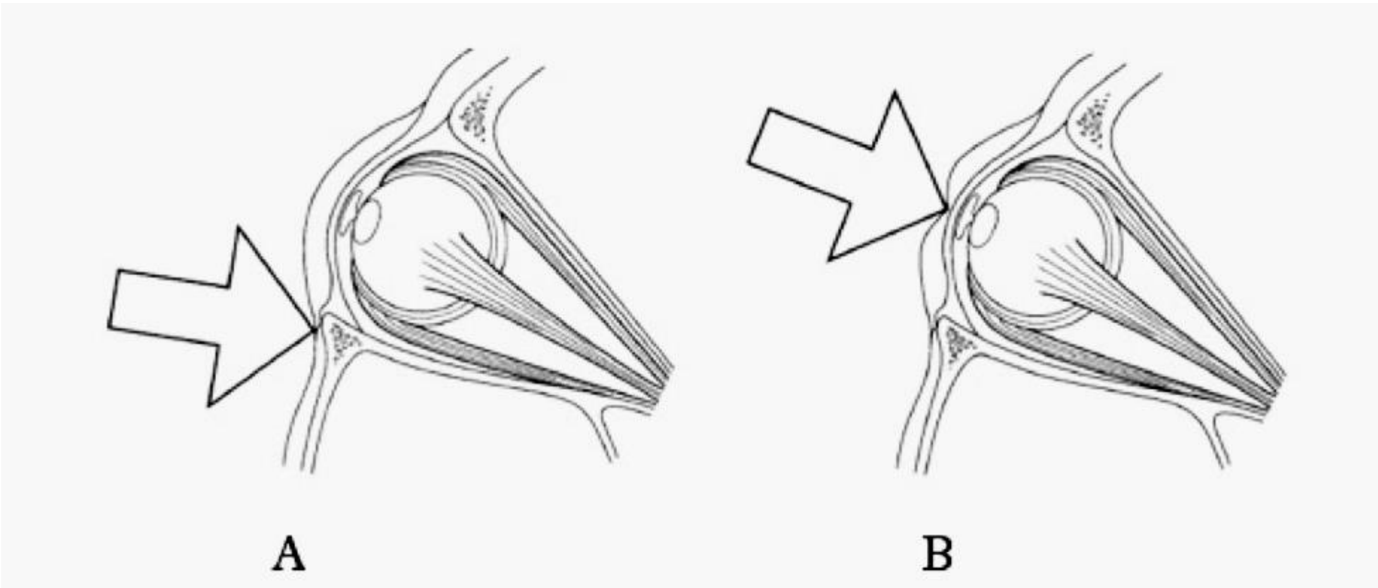

Figure 5: Mechanism of orbital floor fracture (Waterhouse et al., 1999).[18]

A: the bone buckling theory: Schematic representing buckling theoretical mechanism of orbital floor fracture. Force is directed toward inferior orbital rim and transmitted along orbital floor, creating a fracture

B: the hydraulic theory: Schematic representing the hydraulic theoretical mechanism of orbital floor fracture. The globe is retropulsed by a force, the intraorbital pressture increased, the force is transmitted to all of the walls of the orbit, the floor is fractured.

In 1943, Pfeiffer suggested that these fractures were results of transmission of the force of trauma directly from the 'retropulsed' globe toward the orbital floor. A hydraulic theory was first proposed by King. The theory explained for orbital blow-out fractures was a trauma transmitted through the eye to the orbital floor.[11] The subsequent works by Smith and Regan, Jone and Evan demonstrated an experimental support for the hydraulic mechanism of blow-out fracture.[12, 13]

Another mechanism has been postulated by Fujino[14] following an experimental study on dried human skulls without orbital contents. He suggested that direct compression or a buckling force was the causative factor for blow-out fracture. He also reported that the force necessary to produce a blow-out fracture by pressure exerted on the globe was 10 times greater than the pressure required on the infraorbital rim. He argued that this amount of force applied to the globe would cause a high incidence of ocular injury.

These findings supported the theory first hypothesized by Le Fort, who also believed that orbital floor fractures were produced by the force of the injury transmitted through the orbital rim directly to the floor.[17]

The buckling theory does not explain fractures of the medial wall and it cannot easily explain soft tissue displacement or entrapment within the fractured walls of the orbit. However, Fujino and Makino [13] with the use of high-speed photography showed that when a sudden force is applied to the infraorbital rim of an epoxy model of the orbit, a linear fracture of the orbital floor occurs through buckling caused by the posteriorly displaced infraorbital rim. This will tear the periorbita, and the orbital soft tissues are forced into the maxillary sinus by their attachment to the displaced orbital rim and floor, anterior to the linear fracture. Once the force is relieved, the bone springs back to the normal position, but the soft tissue does not return as quickly, causing an entrapment within the fracture.

Fujino and Sato[16], in order to confirm the conclusion of the previous two dimensional eye model, carried out an impact test utilizing a three dimensional eye model. Three kinds of eye models were made, consisting of orbital walls alone, orbital walls with orbital contents, but without the eyeball, and orbital walls, orbital contents and the eyeball. Three impact tests were performed; impact to the infraorbital margin, the eyeball or both the eyeball and infraorbital margin.

They concluded that impact to the eyeball alone did not increase the infraorbital hydraulic pressure sufficiently enough to cause an orbital floor fracture. When the impact struck the infraorbital margin, the orbital floor was displaced laterally and finally fractured by the bending stress/buckling force.

In conclusion, another several literature reviews would suggest that there is reliable evidence that both hydraulic and bucking mechanisms can produce blow-out fracture of the orbit, but with different characteristics and clinical features. Presence of medial /and or large posterior blow-out fractures; incidence of ocular injuries and orbital tissue herniation may suggest the likelihood of involvement of hydraulic mechanism. Whereas, it seems that the role of buckling mechanism is more evident in paediatric trapdoor blow-out fractures.[18-21]

3.4 Symptoms and signs of acute orbital floor fracture

After an orbital floor fracture, the external examination may reveal only subconjunctival haemorrhage, periorbital edema and ecchymosis (Figure 6).

Figure 6: This picture demonstrates subconjunctival haemorrhage, periorbital edema and ecchymosis.

If the orbital rim is involved in the fracture, the patient may demonstrate a palpable bony "step-off" and the complaint of pain with palpation of the rim. An ipsilateral injury to the infraorbital nerve can cause hypesthesia, dysesthesia, or hyperalgesia. Hertel exophthalmometry may demonstrate either proptosis or enophthalmos and should be documented. Unusually severe orbital edema may be associated with more severe fractures and can cause proptosis. Once the edema has subsided, which is usually 1–2 weeks, enophthalmos may be present. However, one must consider proptosis from retrobulbar or peribulbar hemorrhage as well; if present and severe, it can be vision threatening.[22, 23, 24, 25]

Periorbital emphysema is a benign, transient collection of air associated with small orbital fractures communicating with the paranasal sinuses. This sign may be detected by a 'crackling' sensation on palpation of the bony orbit. This benign, large collection has the potential to cause central retinal artery occlusion, and should be managed appropriately. Patients with orbital fractures should be instructed to avoid Valsalva's maneuver, such as nose blowing, to avoid orbital emphysema.[26, 27]

Diplopia occurs as a result of stimulation of non-corresponding points of two retinas by the same object. The etiology of diplopia is likely to be multifactorial. However, it would appear that a combination of orbital soft tissue injury and variable degree of tissue involvement in the defect are the most probable causes for diplopia in the orbital floor fracture of orbit. [28]

Limited vertical movement may be due to the entrapment of inferior rectus or perimuscular fascia into the fracture site. The case of possible entrapment, one must assess for the signs of the oculocardiac reflex: bradycardia, nausea, and syncope.[22, 29] Also, a subclass of orbital fracture with entrapment is called "trapdoor" fracture in children.[22, 30] These fractures show minimal bony displacement and can present with an external examination that appears to be relatively benign. Children may be more prone to pure trapdoor fractures than adults, and incarceration of the muscle in such fractures can lead to permanent damage of the neuromuscular complex. In addition to the entrapment, a limitation of extraocular muscle motility due to orbital edema or traumatic palsy of the third nerve branch to the inferior rectus may cause decreased extraocular movements. If a question exists, forced duction testing may help to clarify the etiology.[22]

3.5 Diagnostic method

For most orbital fractures, the imaging study of choice is the computed tomography (CT) scan. A CT scan with axial and coronal views is optimal. Imaging should be done with thin cuts (2–3 mm), paying specific attention to the orbital floor and optic canal. However, when the patient has severe head and neck trauma, the radiologist may have difficulty positioning the patient to obtain coronal views. Because these views are generally the most helpful for evaluating the integrity of the orbital floor, very thin axial cuts should be obtained to allow reconstructed coronal views to be created (Figure 7).

Figure 7: Coronal computerized tomography scan head; this image demonstrates a fracture of the floor of the left orbit.

The CT scan offers distinct advantages over other imaging modalities. The size and morphology of the fracture can be determined, which aids in not only a clinical assessment but also a surgical planning. The CT scan can determine whether the fracture involves the optic canal. This imaging technique can also reliably demonstrate whether acute proptosis in a patient is secondary to orbital hemorrhage, a potential vision-threatening emergency, or orbital emphysema. This scan can also help detect the entrapment of rectus muscles, recognized by a displacement of the muscle into the fracture site, with or without the bone displacement.[22, 31]

3.6 Treatments of orbital floor fracture

3.6.1 Conservative management

Patients should be advised to avoid blowing their nose for several weeks after the injury to prevent orbital emphysema and possible visual compromise. Nasal decongestant sprays are often used. Many physicians also use prophylactic antibiotics to prevent possible orbital cellulitis from bacterial spread if a fracture creates a direct orbital communication with the sinuses. When orbital edema is severe, steroids may be used to decrease orbital edema, whether or not surgery is indicated.[22]

3.6.2 Surgical management

The criteria for surgical intervention in blowout fractures of the medial and, more commonly, inferior orbital wall are controversial and often debated. Currently, three general guidelines are commonly agreed on for the surgical intervention.

- Diplopia due to limitation of motility with a positive forced duction test and radiologic confirmation of an orbital fracture suggests the entrapment of rectus muscles or the perimuscular tissues. If diplopia is still present several days after trauma, the repair is indicated.
- Enophthalmos that is greater than 2 mm for 14 days after trauma and cosmetically significant to the patient can be an indication for surgery. Orbital

edema that is present initially may mask any enophthalmos. Therefore, exophtalmometry must be rechecked once the orbital edema has subsided. This usually occurs between 10 days and 2 weeks after injury.

- A fracture involving one half or more of the orbital floor, especially when associated with a medial wall defect, usually leads to a cosmetic and/or functional deformity. If left unattended, these fractures tend to result in significant enophthalmos; therefore, the size of the fracture in these cases can be an indication for repair.[22, 32, 34]

When surgery is indicated, many believe that it is usually best performed as close to 2 weeks from the trauma date as possible. This allows the swelling to subside and a more accurate examination of the orbit to be performed. Additionally, the scarring usually has not advanced enough to prohibit adequate surgical correction.[33]

3.6.3 Surgical approaches

The orbital floor can be accessed through a conjunctival approach, through a trancutaneous exposure, through a transantral or through a transnasal approach. Access to this region allows for exploration and release of displaced or entrapped soft tissue, thereby correcting any extraocular motility disturbances. In addition, repair of the bony defect with removal or repositioning of bony fragments allows for restoration of the partition between the orbit and maxillary antrum, thereby preserving orbital volume and geometry and eliminating impingement of soft tissue structures.[35-38]

Most of the accesses to the orbital walls are transcutaneous. Several external incisions of the lower eyelid to allow an access to the infraorbital rim and orbital floor have been described as follows. The major difference between these incisions is the level at which they are placed on the skin of the eyelid and the level at which the muscle is transected to expose the orbital septum/periosteum. [39-45] (Figure 8)

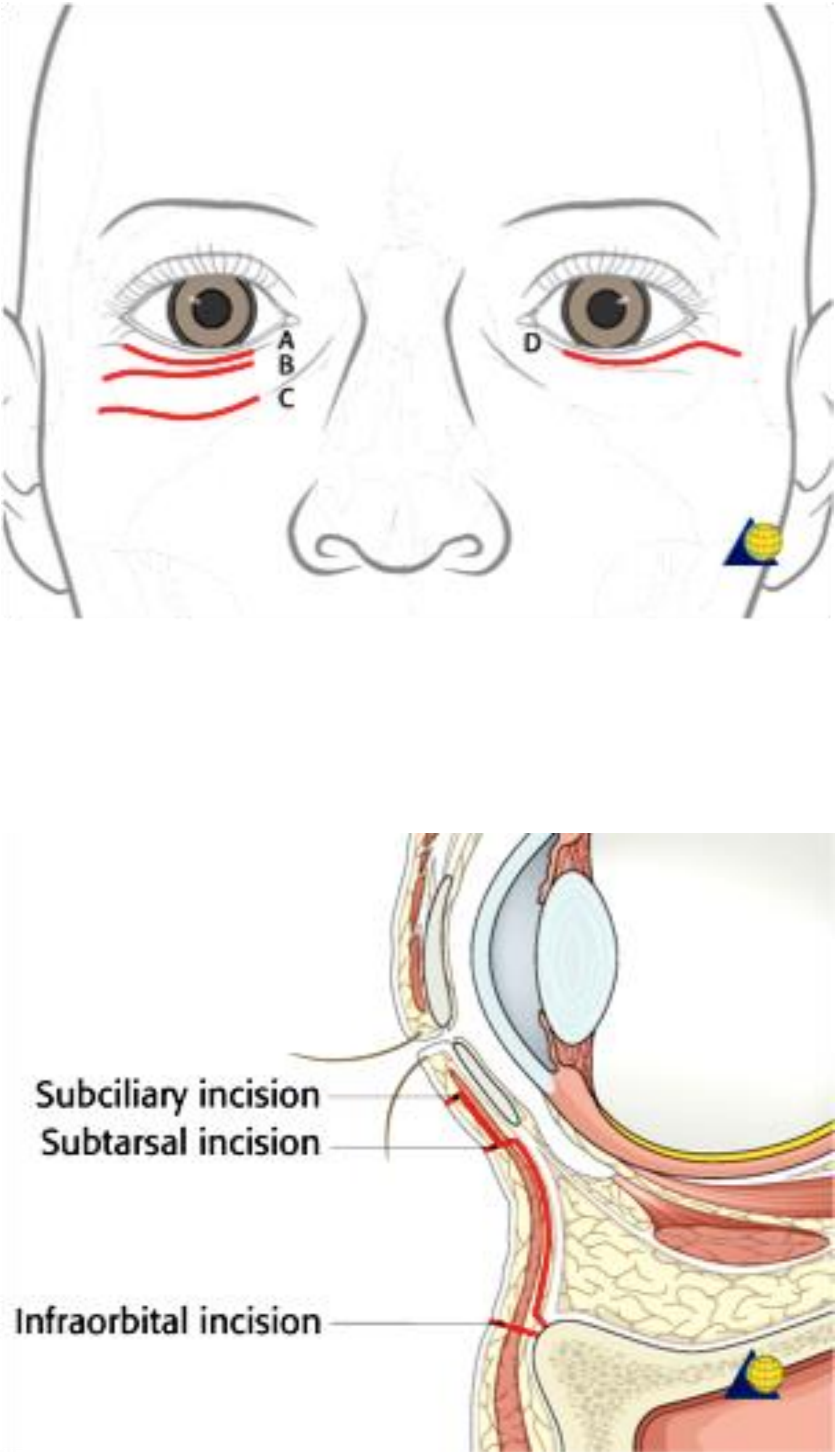

Figure 8: Trancutaneous approach, there are three basic approaches through the external skin of the lower eyelid (AOfoundation, www.aofoundation.org).

3.6.3.1 Subciliary approach

A subciliary cutaneous incision is made 2 mm below and parallel to the lash line. This incision begins at the punctum medially and is continued laterally for about 15 mm beyond the lateral canthus. Three surgical paths are available to access the orbital rim. The skin flap dissection involves dissecting the thin eyelid skin down to the level of the infraorbital rim and divides the orbicularis fibers at the same level as the periosteal incision. The skin-muscle flap technique is subsequently devised. In the nonstepped skin-muscle approach, the cutaneous incision is placed 2 mm below the lash line, traverses both skin and the preseptal muscle, directly atop the inferior tarsal plate, and dissects down the orbital septum, toward the level of the infraorbital rim. The periosteum is then incised and an exposure to the fracture is obtained. The stepped skin-muscle approach divides the orbicularis muscle in line with its fibers approximately 2 to 3 mm below the level of the skin incision, then follows a preseptal plane to the rim and then through periosteum to the orbital floor.[39-44] An intraoperative view of a subciliary incision is demonstrated in Figure 8; the skin flap, the skin-muscle flap (nonstepped) and the skin-muscle flap (stepped) technique are demonstrated in figure 10.

Figure 9: Intraoperative view of a subciliary incision for entering orbital floor

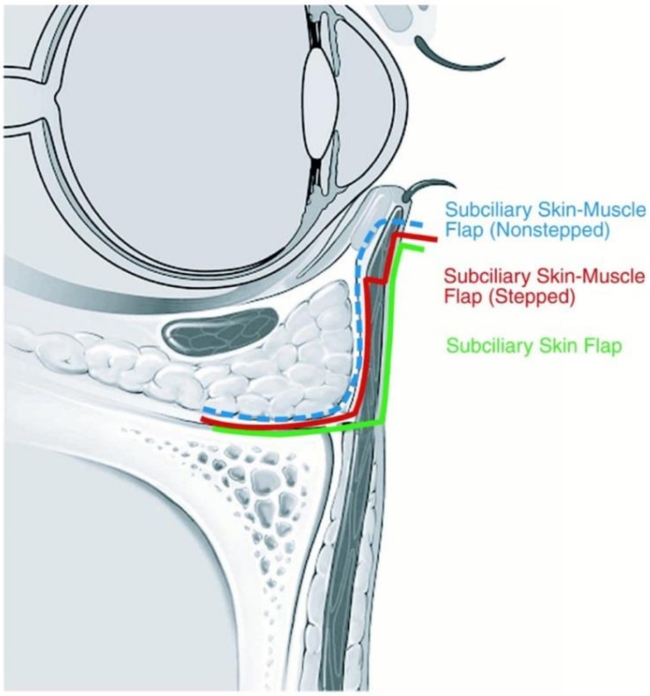

Figure 10: The skin flap, the skin-muscle flap (nonstepped) and the skin-muscle flap (stepped) technique (Rohrich RJ, Janis JE, Adams Jr WP. 2003).[43]

3.6.3.2 Subtarsal approach

The subtarsal incision is also popularized by Converse and is a variation of the skin muscle subciliary technique. The incision is approximately at the level of the lower tarsus, made along in the subtarsal fold. If the fold is obscured by edema, the incision is made approximately 5 to 7 mm from the lower eyelid margin. The orbicularis muscle is then encountered and divided in the direction of its fibers a few millimeters below the skin incision, again to prevent scar inversion. This also preserves all of the innervation to the pretarsal orbicularis and much of the preseptal orbicularis. The incision is then carried down to the level of the infraorbital rim in a preseptal plane. The periosteum is incised and the fracture is exposed. In both the subtarsal and the subciliary incisions, it is important to incise the periosteum on the anterior surface of the rim away from the orbital septum (a few millimeters below the rim) to avoid vertical lid shortening.[39-44] (Figure 11)

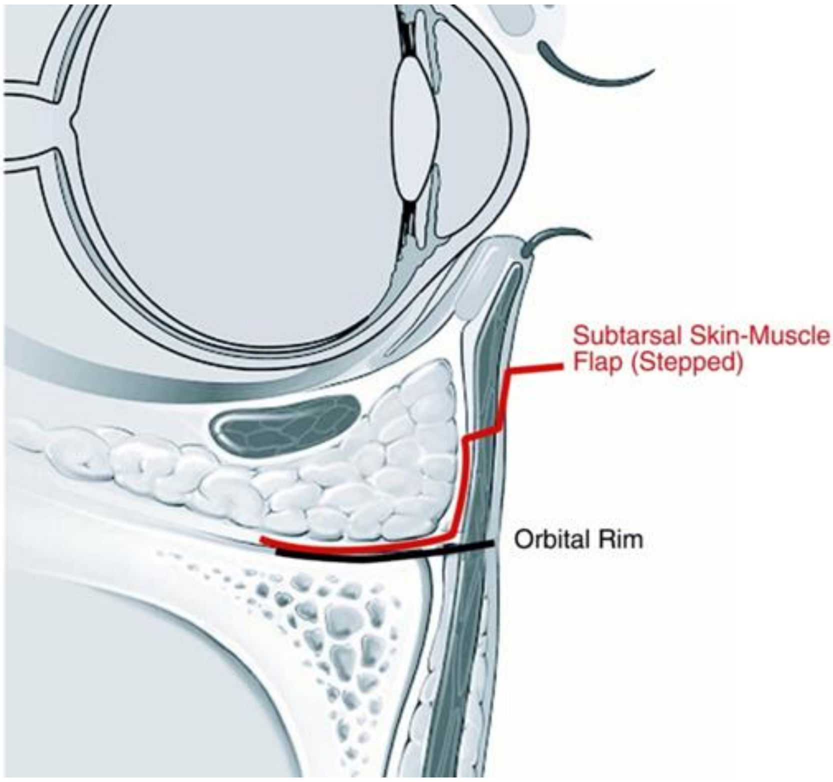

Figure 11: The skin-muscle flap (subtarsal) and the infraorbital approach (Rohrich RJ, Janis JE, Adams Jr WP. 2003).[43]

3.6.3.3 Infraorbital approach

The orbital rim incision is made through skin, subcutaneous tissue, orbicularis muscle, and periosteum directly over the infraorbital rim. The orbital septum remains intact and periosteum is incised at same level as skin incision.[40, 44] (Figure 11)

3.6.3.4 Transconjunctival approach

The transconjunctival approach is initiated with a curvilinear incision from the punctum of the lacrimal canaliculus to the lateral orbital fissure (Figure 12-14).

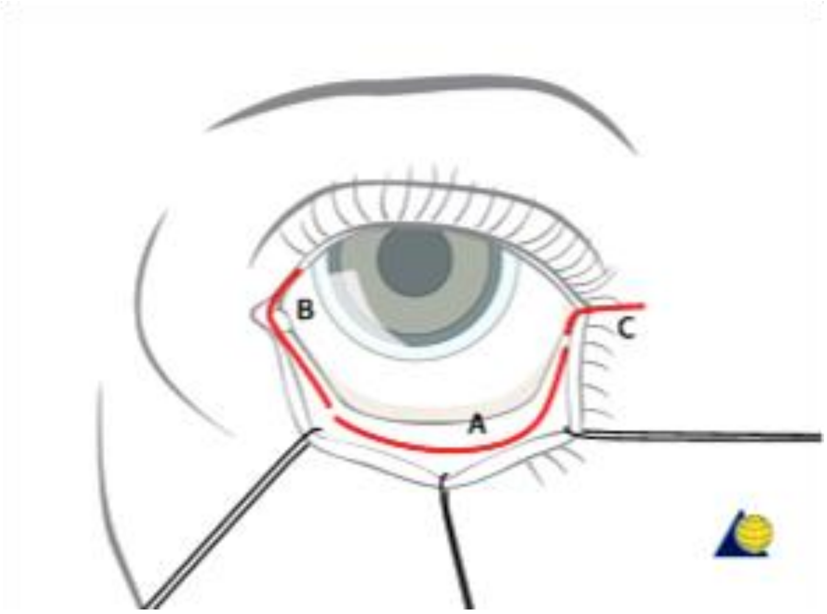

Figure 12: Tranconjunctical approaches are performed in several ways, A: Tranconjunctival, B: Tranconjunctival with lateral skin extension, C: Trancaruncular (AOfoundation, www.aofoundation.org).

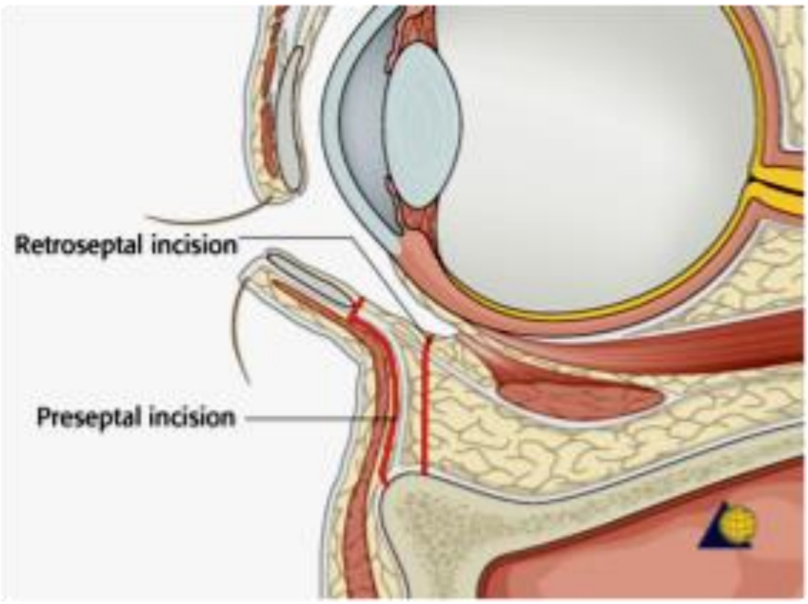

Figure 13: Sagittal section through orbit showing preseptal and retroseptal placement of incision (AOfoundation, www.aofoundation.org).

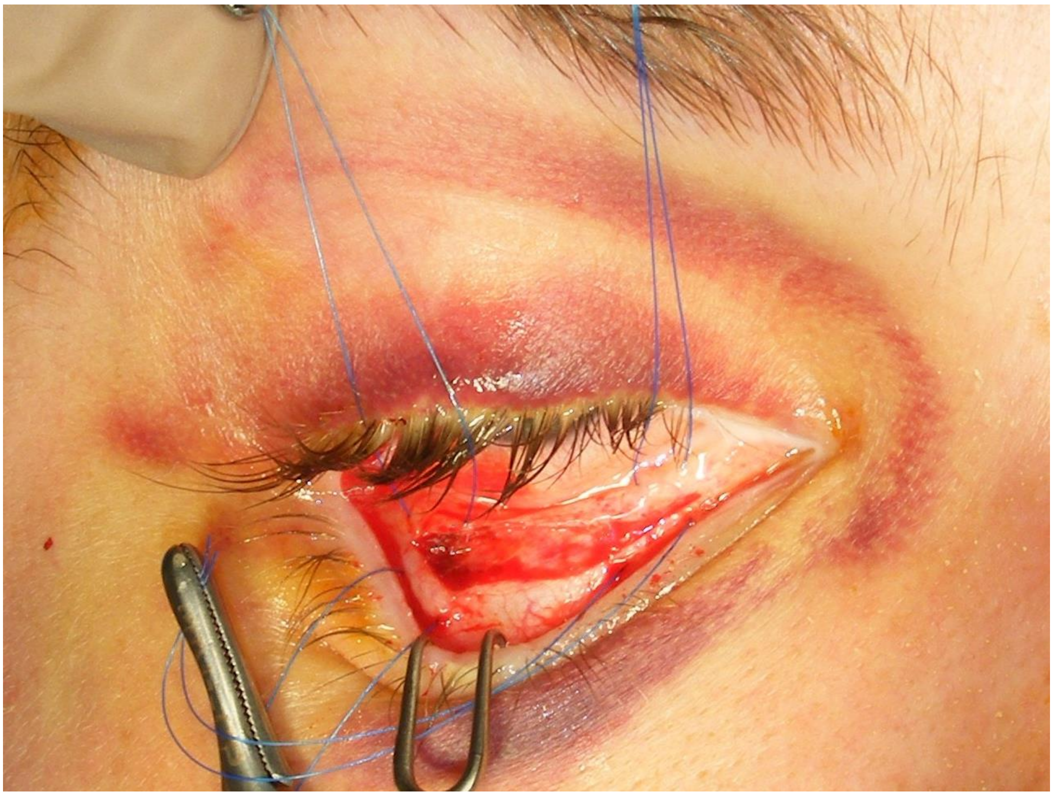

Figure 14: Intraoperative view of a transconjunctival incision for entering the orbital floor.

This incision is placed on the conjunctival surface below the tarsus. A direct plane of dissection is then created and followed over the orbital septum to the inferior orbital rim. It is important to avoid any inadvertent injury to the orbital septum anteriorly during this procedure; otherwise, the periorbital fat will herniate interfering with adequate visualization of the orbital floor. Incision of the periosteum at the medial aspect of the anterior border of the inferior orbital rim is carried out. Then, the periosteum should be elevated with a hand-over-hand technique using sharp periosteal elevators, starting nasally and moving temporally until adequate exposure is obtained. For lateral canthotomy, one tip of pointed scissors is placed inside the palpebral fissure, extending laterally to the depth of the underlying lateral orbital rim (approximately 7-10 mm). The scissors are used to cut horizontally through the lateral palpebral fissure. The structures cut in the horizontal plane are skin, orbicularis oculi muscle, orbital septum, lateral canthal tendon, and conjunctiva. The inferior attachment of the orbital septum should be separated from the inferior border of infraorbital rim. As the orbital septum is completely free, it is lifted upward and inward, thus retracting the orbital contents and giving the surgeon a good view and excellent exposure of the defect.[39-42, 46]

3.6.3.5 Transantral approach

A transantral approach allows access to the orbital floor via the maxillary sinus. This approach may be especially useful when repairing a floor fracture of the trap door variety. The access starts with an upper labial retraction exposing the buccal-gingival sulcus. A horizontal incision just inferior to the buccal-gingival sulcus is created, so that a wide mucosal band is present. A periosteal elevator can be used to strip the anterior maxillary wall of periosteum. The proximity of the infraorbital foramen should be kept in mind to minimize the risk of insult to the neurovascular bundle. The Caldwell-Luc antrostomy must be created with an osteotome and mallet, followed by rongeurs to increase the diameter of the antrostomy, providing access to the orbital floor, medial wall, and ethmoid sinus complex. The mucosa must be stripped from the maxillary antrum and cauterization of the remnants is recommended.

Following the repair of fracture, an attention to hemostasis is indicated by closing the buccal-gingival mucosa with fast-absorbing suture material. This approach results in inferior orbital floor exposure and is not favored for floor fracture repair. Some authors have advocated an endoscopic transantral approach for improved visualization of fractures and to eliminate the need for eyelid incisions.[47]

3.6.3.6 Transnasal approach

Ikeda et al did a retrospective analysis of 11 patients who underwent surgical repair of orbital floor fractures using an endonasal approach. They stated that this approach is a safe and effective technique for the treatment of diplopia. The endoscopic approach enables meticulous manipulation of the repair, as it provides better visualization of the fractured structures of the orbital floor, reducing both intraoperative and postoperative complications.[48]

The transnasal approach for medial orbital defects, either alone or with a transcaruncular or transconjunctival approach to facilitate precise placement of an implant for medial orbital wall reconstruction. This approach has the advantage of adequate visualization of the bony defect and limited risk to intraorbital structures, especially if the operator is experienced with intranasal endoscopic approach. The disadvantages of this approach are the increased risk of skull base injury with CSF leak and limited space for implant introduction.[49, 50]

3.6.4 Materials used for reconstruction of the orbital floor

Implant material for repair of the orbital floor need to perform the following functions: to seal off the antrum from orbit, to provide both a physiological and physical surface to avoid adhesions, to restore the orbital contour and dimension and to give indirect support to the eyeball. The ideal implant material should have three main characteristics: it should replicate the missing tissue; should be easy to handle and should be bio-inert and bio-compatible.[51]

Regardless the choice of implant material, the importance of complete dissection of the orbital floor to demonstrate the entire defect and the intact normally positioned bone surrounding all edges of the fracture.[52] Furthermore, the unique anatomy of the orbit, which dictates the choice of approach needed, has its influence on the type of the implant material to be inserted to replace the defect.[53] The other review on orbital implant material, further specified that the choice for primary orbital reconstruction for acute orbital injuries might differ from the choice of material used for cases of established enophthalmos or hypoglobus. In the chronic cases there could be a change of soft tissue configuration from pyramidal to spherical. This means that the required material should recreate the normal internal anatomy of the orbit.[54]

The choice of implant material for orbital wall reconstruction, either alloplastic or autogenous, is governed by the clinical circumstances and surgeon preference. However, both materials have their advantages and disadvantages, which make the selection for suitable implant material for orbital repair a controversial issue.[55, 56]

Autogenous bone graft for most surgeons is the gold standard material for bone tissue repair. It has been the material of choice for about 40 years. The recommendation for the use bone graft as an implant material based on the fact that it has less risk of infection and low extrusion rate.[58]

There is a particular preference for cranial bone graft because of lower donor site morbidity, and less resorption/ more dimensionally stability, being a membraneous bone.[59] However, an iliac corticocancellous bone graft is ideal for orbital construction. Even with the loss of up to 30% of the thickness of these grafts, the remaining thickness of the grafts closely matches the thickness of the intact orbital floor. The authors pointed out that there is no evidence to support that one biomaterial is superior to another in relation to orbital tissue reaction.[60]

In addition to split calvarial grafts, iliac crest bone grafts are currently considered to be suitable bone graft material.[57] One other suggested donor site is the anterior wall of maxillary sinus.[61] The advantages of this choice is that it obviates the need for two team approach as used in rib or iliac crest grafts, less operation time and there are no external incisions. However, it has the disadvantage of limited size which limits its use to small defects.[58, 62]

Autogenous bone graft, however, has its complications: donor site morbidity; resorption with potential enophthalmos and difficulty of contouring.[63] These drawbacks have led many surgeons to use alloplastic materials.[24] In addition, donor site morbidity makes such bone grafts unsuitable choice for small isolated orbital fractures with minimal possibility of enophthalmos.[64]

Autogenous cartilage grafts have been advocated recently by some researchers. The advantages of autogenous cartilage grafts are that they are easier to harvest and manipulate. They provide long term support as cartilage does not undergo resorption for some considerable time.[57] But the use of nasoseptal cartilage as the material of choice has been advocated in the repair of orbital floor as an easily accessible, available autogenous source with minimal donor site morbidity. Also it is extremely adaptable to the orbital walls.[65] The authors advised the use of 2 layers of nasoseptal graft in large defects. They stress the superiority of nasoseptal graft over alloplastic implant, homografts and bone grafts on the basis of cost, displacement, possibility of infection, operation time and postoperative complications. The auricular conchal grafts have been recommended for small orbital floor defects, being easy to harvest and providing good support/ adequate stability, with minimum donor-site morbidity.[66]

Silastic is a widely used implant material because of its low cost, availability, easy shaping and adequate rigidity.[64] Silastic material's resistance to phagocytosis by immune cells would enhance fibrous tissue capsule formation around it. This capsule makes it tolerable by the body and once stable the long term existence of the material would be unproblematic.[51]

Another widely recommended material is porous ultra-high density polyethylene ('Medpor'®). This material has been used successfully for about 20 years in the surgical repair of orbital defects.[57] Medpor® is recommend because it was a biocompatible and adaptable material with long-term stability.[67] It has good resistance to stress and the presence of pores facilitate vascular in-growth, decreasing the chance of infection. Moreover Medpor® implants satisfactory as their smooth surface when placed under the orbital tissue decreases scar tissue formation, can be shaped to fit, and the presence of channels makes it easy to use with titanium miniplates. The study in a series of 42 patients used Medpore® as their first choice material for reconstruction of orbital floor defects in blow out fractures.[68]

The analysis on 268 patients with orbital floor fractures reported orbital floor reconstruction by autogenous bone graft, titanium mesh, Medpor® and lactosorb implant systems, they concluded alloplastic materials are a suitable substitute for autogenous bone grafts if the latter is contraindicated or by surgeon preference.[69] Furthermore, the other study in 16 paediatric and adolescent patients used soft dura substitute and thin polyethylene sheet. They found that the use of an alloplastic implant material on top of the fracture lines after soft tissue release ensured adequate support with no re-entrapment.[70]

The medical records of 331 blow-out fractures' patients, 106 patients had surgical repair with Macropore and 225 patients were treated with Medpor®, they found that both materials provided a satisfactory outcome and there was no significant difference between the two materials in term of ocular motility and enophthalmos.[71]

Absorbable polymers have also been used over the last three decades. These materials are easily shaped to the defect, well tolerated and offer more predictable absorption compared with biological grafts.[57] The use of biodegradable lactosorb implant materials with resorbable screws have been advocated for sizeable orbital floor defects to avoid donor site morbidity and the need for removal.[72] The reviewed in 435 patients with an orbital fracture reconstructed by lyophilized dura-patches, polydioxanone (PDS) foils, and Ethisorb® biodegradable material, they recommend Ethisorb® because of its low complication rate.[73]

The used of Ethisorb® synthetic resorbable patches, which was originally designed to bridge dura mater defects, for orbital floor reconstruction. The results of their study demonstrated the effectiveness of Ethisorb® in the repair of small to moderate size orbital defects.[74]

The comparison autogenous bone grafts and bioresorbable poly-L/DL-Lactide implants to repair inferior orbital wall defects can concluded, that there is no disadvantage in bridging orbital defects using biodegradable materials.[75]

The study to compare auricular cartilage graft and absorbable polyacid copolymer in 20 patients with blow-out fractures of the orbit found no difference between the two materials in term of both functional and aesthetic outcome.[76]

Metal, titanium mesh in particular has also been widely used for orbital floor defect repair. This material is highly biocompatible, with osteo-integration and mechanical properties which make it a suitable substitute for bone.[57] The both bone and titanium mesh can be successfully used to reconstruct isolated blow-out fractures of the orbit. Furthermore, irrespective of the material used in reconstruction, the soft tissues of the orbit were adequately replaced. However, they suggested that titanium mesh is more suitable for posterior defects.[77]

The pre-operatively preformed titanium mesh implants, based on 3D CT models, to be more precise, less invasive and less time consuming compared to ‘free hand’ formed titanium mesh or calvarial grafts. This technique precisely predicted the required reconstruction for complex orbital defects involving more than one orbital wall.[78] However, clinical application of three dimensional, pre-bent titanium mesh for orbital floor fracture surgery was financially viable and clinically practical.[79]

Disadvantages of titanium implants include possible ‘edge abrasion’ upon shaping of the metal to suit the defect, and late complications such as infection, metal corrosion and toxicity. To overcome some of these problems a new titanium mesh, covered on both sides by a thin sheet of polyethylene material, has been recently introduced.[57]

Size of the fracture defect and volume loss might influence the choice between single or 2 implant materials. The use of single implant material has been recommend in small to medium size defects, and a combination of different materials in large orbital defects and the use of calvarial bone graft combined with a wedge of irradiated homologous costal cartilage placed behind the globe to repair post-traumatic enophthalmos.[80, 81]

Despite the choice of materials available for orbital floor defect reconstruction, there appears to be a tendency toward the use of titanium mesh and porous Medpor® in orbital wall reconstruction.[51, 54] Nevertheless, the choice of the implant material is still highly dependent on operator's preference. This might be explained by the interaction between the factors that influence the choice, which are the advantages and disadvantages of each material, and the nature, the shape and the size of the defect and expected complication in each particular case.

3.6.5 Complications associated with trancutaneous and transconjunctival approaches

The transcutaneous approaches (subciliary, subtarsal, infraorbital) are better for a wider exposure of the orbital floor, but risk an external scar. The subciliary approach seems to be falling out of general favor, as an extensive review of the plastic surgery literature has revealed a significantly increased risk of postoperative ectropion. The possible reason of postoperative ectropion is that the subciliary approach causes scarring at the anterior and middle lamellae of the eyelid. To minimize the incidence of postoperative ectropion, the pretarsal portion of the orbicularis oculi muscle should be preserved to support the lower lid and lessen the effects of scar contracture.

Although uncommon, complications from the transconjunctival incision exist. Improper dissection can cause canalicular injury or a buttonhole full-thickness laceration of the lower eyelid. Early transient complications can include edema, epiphora, chemosis, trichiasis, and diplopia. Later complications include conjunctival granuloma, ectropion, entropion, intractable chemosis, lower lid retraction, and lower lid malposition secondary to postoperative scar and excessive retraction. The percentage of all complications across the literature is approximately 10%, with most of the complications resolving with observation.[48]

The most common complication requiring intervention is entropion. The possible reason of postoperative entropion is scarring of the posterior lamella. Once the scar becomes mature and shrinks, it therefore creates the inward retraction. The incidence of complications likely increases with the length of the surgical wound. Ridgway et al reported the complication rate of 4% (2 of 45 cases) when combined with lateral canthotomy and inferior cantholysis in addition to subperiosteal exposure along the body of the zygoma for ZMC fracture repair. [82-92]

3.7 Rationales and objectives of the presented work

In the Department for Oral and Maxillofacial Surgery of the University Hospital of Leipzig, the subciliary approach was frequently used until 2007. Transconjunctival incision has been rather an exception. Most of the fractures have been treated with the implantation of PDS-foil. In 2005 to 2007, there was a turnaround in the treatment of orbital wall fractures. New implant materials, especially titanium meshes, have been established by the industrial suppliers. As a result of this development, an improved outcome regarding symptoms like diplopia and enophthalmos could be stated. The bulky metal meshes required more extended incision, especially in the medial direction. This extension is not possible in subciliary incision because of the lacrimal duct. These circumstances and the trends in literature have been reasons to change our surgical approach to the orbital floor and to leave the subciliary incision. The transconjunctival incision became the method of choice after 2007/2008. This approach has gained wide acceptance in the treatment of orbital fractures because of certain advantages it has over the more traditional transcutaneous approaches. Not only that the transconjunctival approach gives the greater exposure of the orbital floor, the caudal part of lateral and medial walls (performing a retrocaruncular extension, lateral canthotomy), but this approach can also provide better esthetic results.

The special history of surgical approaches in our unit gave us the opportunity to compare two different groups of incisions (subciliary versus transconjunctival approach). Although both surgical approaches have been used for 70 and over 40 years, respectively, there is no consensus regarding the most appropriate incision to prevent postoperative lower eyelid complications.[29, 40, 41] The main objective of this study was to compare the frequencies of postoperative lower eyelid complications in subjects receiving a subciliary to those receiving a transconjunctival approach in restoring orbital floor fractures. The study was already published by Pausch et al. (2015).[93]

4 Materials and methods

4.1 Study design and sample

This was a retrospective cohort study recruiting all subjects who presented to the Department of Oral, Craniomaxillo facial and Facial Plastic Surgery, University Hospital of Leipzig, for evaluation and treatment of orbital floor fractures between January 1, 2001, and December 31, 2010. To be eligible for the study, the subjects must have at least one orbital floor fracture explored/repaired via a subciliary or a transconjunctival approach, and attended the follow up appointments at least 6 months postoperatively.

Subjects were excluded from the study when they had preexisting conditions that could affect wound healing or predispose them to postoperative lower eyelid complications, including previous radiation therapy to the maxillofacial region, human immunodeficiency virus infection, organ or marrow transplant candidates or recipients, or organ failure (kidney, heart, liver); were currently on oral steroid therapy; had local pathology, e.g., scarring, tumor, or keratoconjunctivopathy; or acute local inflammation characterized by frank purulence, erythema, or induration.

This study was exempted from the institutional ethical review because it did not involve human subjects directly. We followed all the guidelines set forth by the Declaration of Helsinki.

4.2 Study variables

The predictor variable was the surgical approach, which was as a binary variable (subciliary or transconjunctival). For the subciliary approach, the skin incision was made 1–2 mm below and parallel to the lower eyelid margin. We used a skin-muscle flap because the skin-only flap is prone to soft tissue complications. The further dissection was carried down to the tarsal plate, which was followed in a preseptal plane. Finally, the periosteal incision exposed the infraorbital rim. In the transconjunctival group, we incised the inner conjunctiva below the tarsal level, from the caruncle medially to the lateral fornix. We then followed the septal plane until the orbital rim. We did not perform lateral canthotomy or inferior cantholysis in any cases. Once necessary, alloplastic implants, e.g., polydioxanone or Vicryl sheets, or titanium meshes, were used to repair the orbital floor. After the fracture was repaired, we used a 6-0 absorbable Vicryl suture to reapproximate the orbicularis muscle and conjunctiva, and the skin was sutured with 5-0 or 6-0 Prolene.

The primary outcome variable was postoperative lower eyelid complications (ectropion, entropion, and eyelid retraction). Shape and position of the lower lids was assessed at three different observing times: (1) immediately after the traumatic event as the preoperative baseline; (2) 7 days after the surgery; and (3) 6 months postoperatively. For this study, we defined ectropion as a visible eversion of the lower eyelid margin of at least 1 mm within the lid course and a missing contact of the lid and the bulbar conjunctiva, as demonstrated in figure 15.

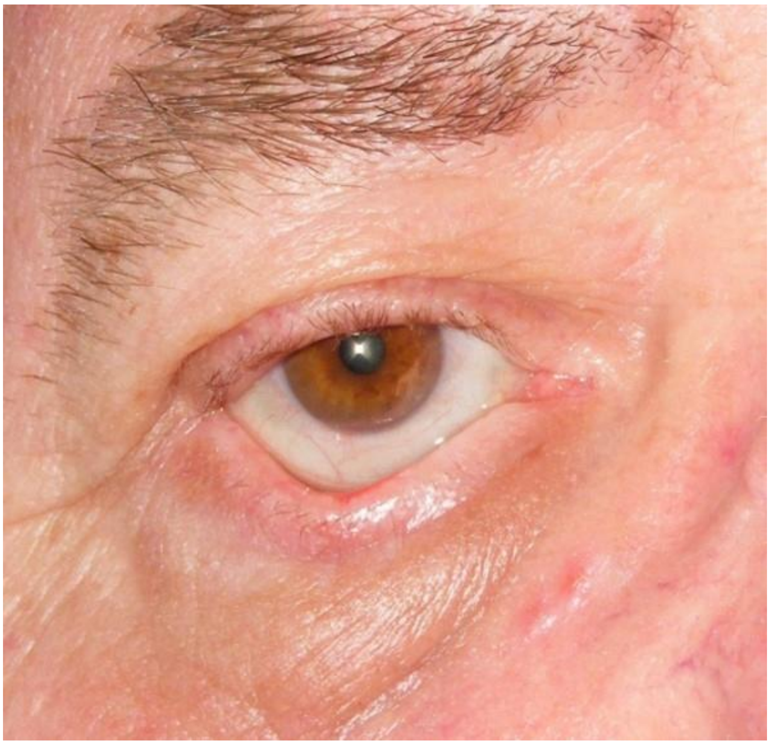

Figure 15: Eversion of the lower eyelid margin within the lid course, missing contact of the lid and the bulbar conjunctiva on the right eye (study criteria for ectropion)

Entropion was recognized as a visible inversion of the lower eyelid margin of at least 1 mm within the lid course according to figure 16.

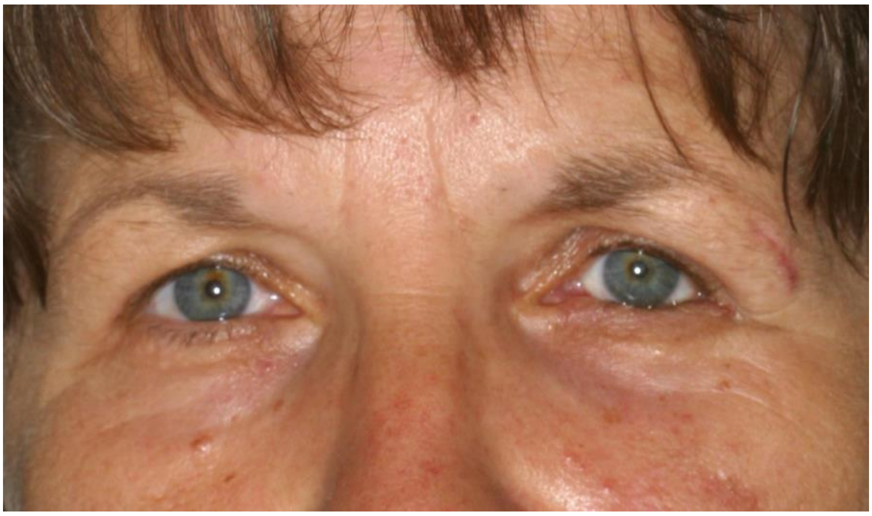

Figure 16: Inversion of the lower eyelid margin within the lid course on the left eye (study criteria for entropion).

Lower lid retraction referred to any vertical shortening of the lower lid with visible scleral show of at least 1 mm [94, 95], but preserved contact of the lid to the scleral surface, according to figure 17.

Figure 17: Vertical shortening of the lower lid and visible scleral show without loss of contact on the right eye (study criteria for lower lid retraction)

All patients were examined by an ophthalmologist on the hospitalization day, immediately postoperatively and after resolution of soft tissue swelling within the first 7 days after the surgery. A followup investigation was performed 6 months after the operation.

Other study variables were collected on four sets of heterogeneous variables grouped as demographic, anatomic, or operative. Demographic variables included gender, age, and causes of injuries. Anatomic variables included the side and the extent of the injury. Operative variable was time to surgery, defined as the number of days from the injury to the surgery.

4.3 Data entry and data analysis

Prior to entry, all data were reviewed for accuracy and completeness. The investigators designed and implemented the data sheet and data entry programs, including appropriate checks for accuracy. A database was constructed and analyzed using the software R version 2.14.1.

Data analyses included calculating the appropriate descriptive and univariate statistics. The primary analysis of interest was to measure the association between surgical approach (subciliary or transconjunctival) and postoperative lower eyelid complications. A P value ≤ 0.05 was considered statistically significant.

5 Result

During the 10-year study period, 361 subjects presented orbital floor fractures. Nine and five patients underwent the surgery via a subtarsal approach and preexisting laceration, respectively, and one patient denied the treatment. Hence, 346 (95.8 %) subjects met the inclusion criteria for the study and their data were analyzed. Demographic, anatomic, and operative data were presented in Table 1.

Table 1 Descriptive statistics of the study cohort (n = 346)

Measures	Patients
Gender (female)	98 (28.3)
Age (years)	42.7 ± 21.1 (range, 5-89)
Side of injury	
Right	152 (43.9)
Left	181 (52.3)
Extent of injury	
Unilateral	333 (96.2)
Bilateral	13 (3.8)
Type of injury	
isolated orbital floor fracture	156 (45.1)
associated with zygomatic fracture	141 (40.7)
associated with other facial fracture(s)	49 (14.2)
Causes	
alcohol-related	84 (24.3)
physical assaults	125 (36.1)
falls	98 (28.3)
traffic accidents	70 (20.2)
sport	23 (6.6)
daily life activities	22 (6.4)
work-related	4 (1.2)
unidentified (eg, sneezing, nose blowing)	4 (1.2)
Time to surgery (days)	4.3 ± 4.1 (range, 0-44)

NOTE: Categorical data are presented as number (percentage). Continuous data are listed as mean ± SD.

At the immediately postoperative follow-up, there was no ectropion, entropion, or eyelid retraction. Lower eyelid complications at 7 days and 6 months after the surgery were shown in Table 2.

Table 2 Univariate analyses of study variables (n = 346; Fisher's exact test)

Study variables	Subciliary approach	Transconjunctival approach	*P*-value
Total	225 (65)	121 (35)	NA
7 days postoperatively			
ectropion	12 (5.3)	1 (0.8)	**0.0324**
entropion	0	5 (4.1)	**0.005**
eyelid retraction	1 (0.4)	0	1
6 months postoperatively			
ectropion	8 (3.6)	0	**0.03**
entropion	0	3 (2.5)	**0.0421**
eyelid retraction	0	0	1

NOTE: Categorical data are presented as number (percentage). Statistically significant *P*-values are indicated in **bold** typeface.

The subciliary approach was significantly linked to the higher rates of ectropion and the lower rates of entropion at 7 days and 6 months postoperatively. There was no statistically significant difference in the frequency of eyelid retraction between both groups (Figure 18-20).

At 6 months postoperatively, there were eight patients with ectropion and three patients with entropion. Only five ectropion patients underwent surgical correction (reinsertion of the lower lid retractors and creation of the lateral canthal support with/without a Frost suture or auricular skin grafting), two patients rejected the further treatment, and the other one lost to follow-up. After the ectropion correction, four patients showed improvements and the other patient had permanent ectropion but declined further treatment.

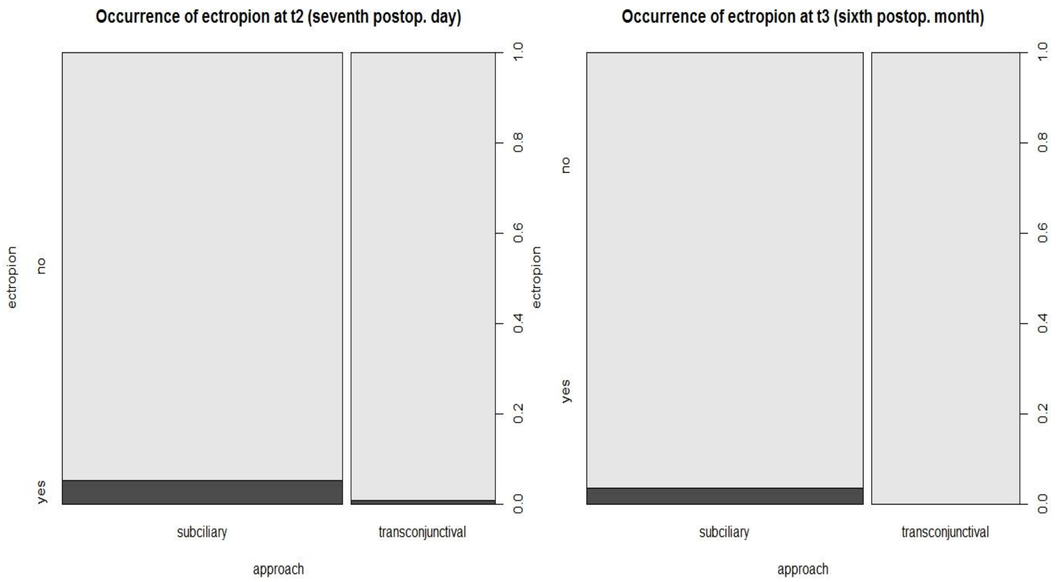

Figure 18: Occurence of the event „Ectropion“ at the time of investigation t 2 and t 3 in the spine diagram

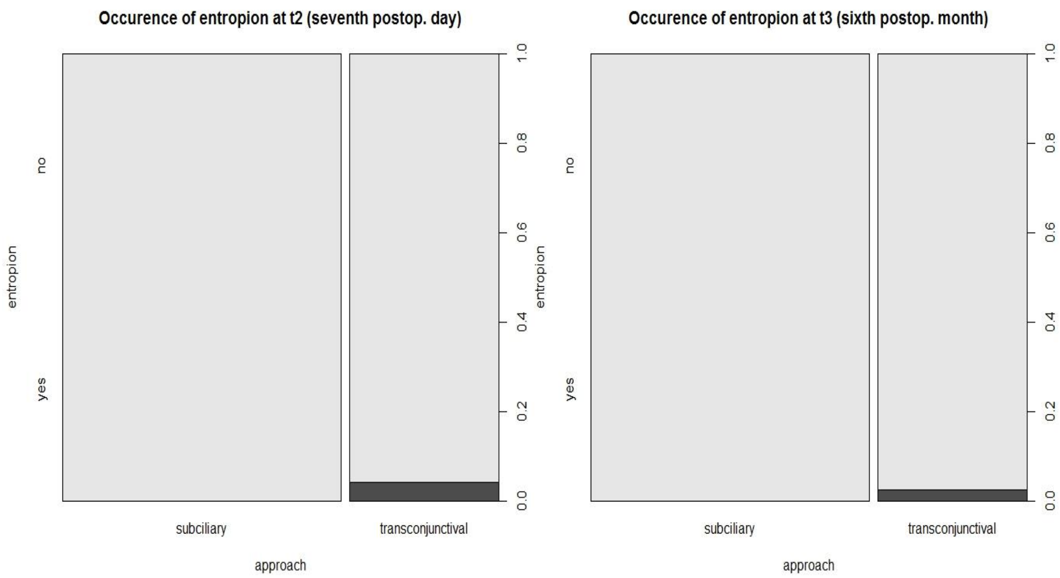

Figure 19: Occurrence of the event „Entropion“ at the time of investigation t 2 and t 3 in the spine diagram

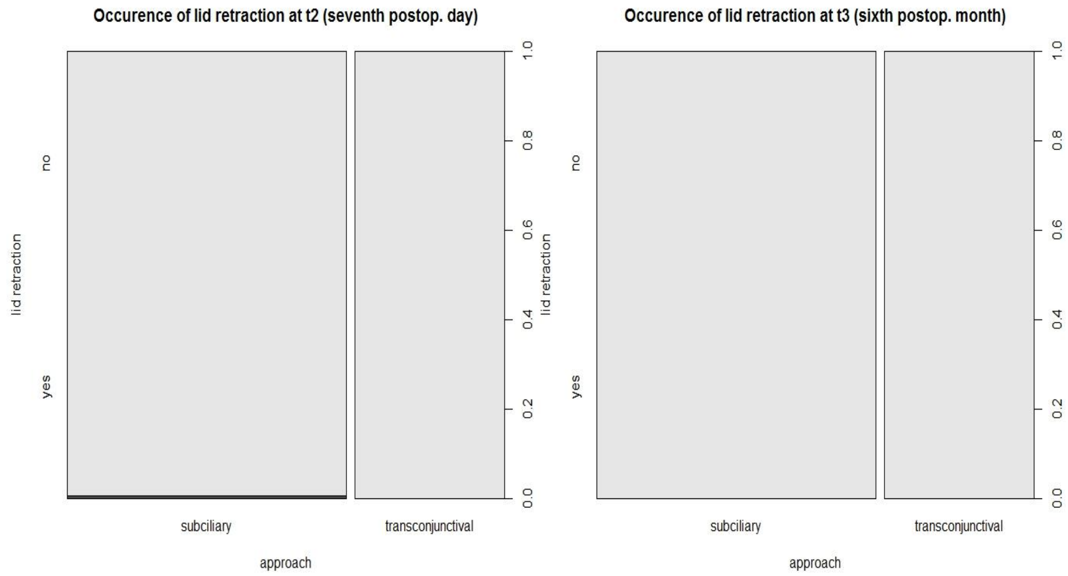

Figure 20: Occurrence of the event „Lid retraction“ at the time of investigation t 2 and t 3 in the spine diagram

One of the three patients with entropion rejected the treatment; the other two patients were opted to surgical revision (reattaching the lower eyelid retractors to the inferior border of the tarsus and grafting with buccal mucosa). The results in these two patients were uneventful and clinically satisfied.

One case presented with temporary lower eyelid retraction after a subciliary approach at 7 days after the surgery. However, it disappeared 6 months postoperatively after conservative treatments with massage, ointment, and steroid injection.

6 Discussion

The aim of this study was to compare the frequencies of lower eyelid complications after the use of a subciliary or a transconjunctival approach to expose orbital floor fractures. We hypothesized that the frequency of postoperative lower eyelid complications was equal between the two groups (subciliary vs. transconjunctival). Using the standard postoperative follow-up protocol (with the collaboration of our ophthalmologist colleagues), we found that the subciliary approach was linked to the higher frequency of ectropion, while entropion was more often in the transconjunctival group.

Indeed, the orbital floor can be exposed through various incisions, such as subciliary, transconjunctival, and infraorbital approaches or even directly through laceration from the injury. However, the first two incisions have gained popularity over the past decades. It is generally accepted that all surgeries can lead to complications [40, 43, 96]. With regard to complications, the infraorbital incision causes a low incidence of ectropion but an increased incidence of poor scarring. Ectropion is the major concern after a transcutaneous approach and often associated with the subciliary or blepharoplasty incision. To minimize the incidence of postoperative ectropion, the pretarsal portion of the orbicularis oculi muscle should be preserved to support the lower lid and lessen the effects of scar contracture. [41, 42]

The transconjunctival approach, with or without lateral canthotomy and cantholysis, has been found to be associated only rarely with lower lid malposition (e.g.,ectropion) compared to the transcutaneous approaches. This approach avoids the violation of the lower eyelid skin and orbicularis oculi muscle, resulting in a reduced tendency for postoperative lower eyelid retraction, scleral show, and ectropion. However, the transconjunctival incision may occasionally be impossible due to factors that obliterate the inferior fornix, such as persistent chemosis, orbital proptosis, intense lower eyelid edema, or traumatic lower eyelid avulsion or injury. In these cases, a transcutaneous approach is warranted. [42]

Complications using the transconjunctival approach include transient lower eyelid retraction and scleral show, noticeable lateral canthal scar, and inferior displacement of the lateral canthus. Potential complications including prolonged chemosis, granulation tissue, infection, true ectropion, canthal dehiscence, canalicular injuries, and iatrogenic eye injuries rarely occur. Although granuloma formation along the transconjunctival incision may occur and requires secondary excision, especially when it is distressing to the patient or obscures the visual axis, we did not observe this complication in our series. Cicatrical ectropion due to excessive overlapping of the free edges of the incision along the horizontal extent of the lower eyelid can result in scleral show requiring scar release later. This can be avoided by carefully pulling the lower eyelid superiorly at the end of the operation to prevent any incisional overlap or by suspending the lower eyelid with a Frost suture or Steri-strips for 24–48 h. Overall, the occurrence of ectropion is much lower using the transconjunctival approach than the conventional transcutaneous approach in most studies including our study. [42, 96-98] In our department, we have changed to use the transconjunctival approach in most orbital fracture patients since 2007.

Entropion rarely occurs after contracture of the wound following the transconjunctival approach to orbital floor fractures. In our study, we found three cases (2.5 %) with entropion after the transconjunctival incision. The possible reason of postoperative ectropion and entropion is that the subciliary approach causes scarring at the anterior and middle lamella of the eyelid, while scarring of the posterior lamella can occur after the transconjunctival incision. Once the scar becomes mature and shrinks, it therefore creates the outward retraction in the former and the inward retraction in the latter. Our results confirm the findings of other authors.[97-101]

Our study shows some limitations. The surgical procedures were carried out by multiple surgeons. We included all orbital fractures regardless of their types and severities of trauma. Various implant materials were used. Lastly, the evaluations of the lower lid position were assessed by different persons, which may skew our results.

7 Summary

Dissertation zur Erlangung des akademischen Grades Dr. med. dent.

Title: Lower eyelid complications associated with transconjunctival versus subciliary approaches to orbital floor fractures

Eingereicht von: Nattapong Sirintawat

Angefertigt an: Der Klinik und Poliklinik für Mund-Kiefer- und plastische Gesichtschirurgie der Universität Leipzig

betreut von: Priv. Doz. Dr. med. Dr. med. dent Niels Christian Pausch

1 November 2015

Orbital floor fractures occur frequently as a result of blunt trauma usually from assaults, motor vehicle accidents, falls and sport injuries.

Indications for the surgical repair of orbital floor fractures in adults are diplopia, enophthalmos and large fracture. When repairing orbital fractures, the surgical technique used should provide adequate access and exposure necessary to accomplish the primary surgical repair as well as yield a low complication rate and provide a good functional and cosmetic result.

The orbital floor can be accessed through a conjunctival approach, through cutaneous exposure, or through a transmaxillary approach. Access to this region allows for exploration and release of displaced or entrapped soft tissue, thereby correcting any extraocular motility disturbances. In addition, repair of the bony defect with removal or repositioning of bony fragments allows for restoration of the partition between the orbit and maxillary antrum, thereby preserving orbital volume and geometry and eliminating impingement of soft tissue structures.

The aim of this study was to compare the frequencies of lower eyelid complications after the use of a subciliary or a transconjunctival approach to expose orbital floor fractures. We hypothesized that the frequency of postoperative lower eyelid complications was equal between the two groups (subciliary vs. transconjunctival). Using the standard postoperative follow-up protocol (with the collaboration of our ophthalmologist colleagues), we found that the subciliary approach was linked to the higher frequency of ectropion, while entropion was more often in the transconjunctival group.

Indeed, the orbital floor can be exposed through various incisions, such as subciliary, transconjunctival, and infraorbital approaches or even directly through laceration from the injury. However, the first two incisions have gained popularity over the past decades. It is generally accepted that all surgeries can lead to complications.[6-8] With regard to complications, the infraorbital incision causes a low incidence of ectropion but an increased incidence of poor scarring. Ectropion is the major concern after a transcutaneous approach and often associated with the subciliary or blepharoplasty incision.

The transconjunctival approach, with or without lateral canthotomy and cantholysis, has been found to be associated only rarely with lower lid malposition (e.g.,ectropion) compared to the transcutaneous approaches. This approach avoids the violation of the lower eyelid skin and orbicularis oculi muscle, resulting in a reduced tendency for postoperative lower eyelid retraction, scleral show, and ectropion. However, the transconjunctival incision may occasionally be impossible due to factors that obliterate the inferior fornix, such as persistent chemosis, orbital proptosis, intense lower eyelid edema, or traumatic lower eyelid avulsion or injury. In these cases, a transcutaneous approach is warranted.

Overall, the occurrence of ectropion is much lower using the transconjunctival approach than the conventional transcutaneous approach in most studies including our study.

In our department, we have changed to use the transconjunctival approach in most orbital fracture patients since 2007.

Entropion rarely occurs after contracture of the wound following the transconjunctival approach to orbital floor fractures. In our study, we found three cases (2.5 %) with entropion after the transconjunctival incision. The possible reason of postoperative ectropion and entropion is that the subciliary approach causes scarring at the anterior and middle lamella of the eyelid, while scarring of the posterior lamella can occur after the transconjunctival incision. Once the scar becomes mature and shrinks, it therefore creates the outward retraction in the former and the inward retraction in the latter.

In conclusion, many incisions have been described for approaches to treatment the orbital floor fracture, but no special type of incision has been demonstrated to be superior to another. Given that all approaches have the risk of postoperative complications. The choice of approach is guided by the following goal: good intraoperative visibility, minimal postoperative scar formation and good aesthetic results. These can be achieved using either the subciliary incision or the tranconjunctival incision.

In our study, the total rate of ectropion was significantly higher in the subciliary approach than in the transconjunctival incisions. The total rate of entropion was significantly higher in the transconjunctival approach. The choice of incision can be based on surgeon preference. Nevertheless, the author prefers the transconjunctival approach as an access to the orbital rim because this approach provides excellent surgical access to the inferior orbit and is associated with low incidence of complications and a better aesthetic outcome than the subciliary approach. It can be easily combined with a lateral canthotomy or trans/-

retrocaruncular incision for wide access to the orbital floor, medial and lateral wall. However, the subciliary approach may be an option with reasonable outcome in the hands of an experienced surgeon.

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9 List of figures

Figure 15: Eversion of the lower eyelid margin within the lid course, missing contact of the lid and the bulbar conjunctiva on the right eye (study criteria for ectropion).

Figure 16: Inversion of the lower eyelid margin within the lid course on the left eye (study criteria for entropion).

Figure 17: Vertical shortening of the lower lid and visible scleral show without loss of contact on the right eye (study criteria for lower lid retraction).

Figure 18: Occurence of the event „Ectropion“ at the time of investigation t 2 and t 3 in the spine diagram.

Figure 19: Occurrence of the event „Entropion“ at the time of investigation t 2 and t 3 in the spine diagram.

Figure 20: Occurrence of the event „Lid retraction“ at the time of investigation t 2 and t 3 in the spine diagram.

10 Declaration of self-reliant authorship

(Erklärung über die eigenständige Abfassung der Arbeit)

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbständig und ohne unzulässige Hilfe oder Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Ich versichere, dass Dritte von mir weder unmittelbar noch mittelbar geldwerte Leistungen für Arbeiten erhalten haben, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertation stehen, und dass die vorgelegte Arbeit weder im Inland noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde zum Zweck einer Promotion oder eines anderen Prüfungsverfahrens vorgelegt wurde. Alles aus anderen Quellen und von anderen Personen übernommene Material, das in der Arbeit verwendet wurde oder auf das direkt Bezug genommen wird, wurde als solches kenntlich gemacht. Insbesondere wurden alle Personen genannt, die direkt an der Entstehung der vorliegenden Arbeit beteiligt waren.

1. 11. 2015 .... Sirintawat, Nattapong ....

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12 Publication lists

Lower eyelid complications associated with transconjunctival versus subciliary approaches to orbital floor fractures

Pausch NC, Sirintawat N, Wagner R, Halama D, Dhanuthai K

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Psychosocial acceptance of cleft patients: has something changed?

Pausch NC, Winter K, Halama D, Wirtz C, Yildirim V, Sirintawat N.

Oral Maxillofac Surg. 2015 Jul 28. [Epub ahead of print] PMID: 26212596

Factors affecting scientific productivity of German oral-maxillofacial surgery training centers: a retrospective cohort study.

Pausch NC, Neff A, Subbalekha K, Dhanuthai K, Sirintawat N, Pitak-Arnnop P.

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Grand rounds: Eyelid swelling after nose blowing.

Pausch NC, Neff A, Dhanuthai K, Sirintawat N, Vorakulpipat C, Pitak-Arnnop P.

Am J Otolaryngol. 2014, 35(3):456-459 PMID: 24631455

Comparative study of the novel and conventional injection approach for inferior alveolar nerve block.

Boonsiriseth K, Sirintawat N, Arunakul K, Wongsirichat N.

Int J Oral Maxillofac Surg. 2013, 42(7):852-856 PMID: 23265758

Comparative study of the effect of dexamethasone injection and consumption in lower third molar surgery.

Boonsiriseth K, Klongnoi B, Sirintawat N, Saengsirinavin C, Wongsirichat N.

Int J Oral Maxillofac Surg. 2012, 41(2):244-247 PMID: 22209180

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